THE

ONTARIO WATER RESOURCES

COMMISSION

MIDDLE GRAND RIVER REGION

WATER SUPPLY STUDY

NOVEMBER 1966

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TABLE OF CONTENTS

TABLE OF CONTENTS
(Cont'd)

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENT

The co-operation and advice received during the preparation of this report from employees and representatives of the Provincial Government Departments contacted, the Grand River Conservation Authority, and the Counties and Municipalities in the study area is gratefully acknowledged.

I

PURPOSE AND SCOPE

PURPOSE

This study was undertaken for two main reasons. The first was to provide an inventory of the existing water use in the study area and to evaluate the quality and quantity of the ground and surface water in the region. The second was to attempt to predict the future water supply requirements for this rapidly developing area, to review the various alternatives available and to reach a conclusion regarding the most suitable source of supply to meet the anticipated demand.

SCOPE

The report describes the general characteristics of the region and attempts to predict the future population and general land use patterns. It should be noted that considerable use has been made of the existing and proposed official plans of the area municipalities in forecasting the growth in the region.

On the basis of preceding considerations the necessary water supply requirements have been determined. These figures outline the expected demand for a period of approximately 50 years from the present time during which it is anticipated that development will reach its utlimate areal extent.

In determining the most suitable sources for water supply, an evaluation of the quantity and quality of the water resources of the region and environs, both ground and surface, was made. The recommended sources were chosen utilizing economic, engineering, qualitative and quantitative considerations.

II

SUMMARY AND RECOMMENDATIONS

SUMMARY

The Middle Grand River Region encompasses approximately 30 per cent of the Grand River Basin. This is an area of rapid growth. As such, there is a need for long-range planning of services.

A conservative estimate indicates that an additional 22 mgd of good quality ground water can be developed in the region. If estimates are correct, some mining of the overburden aquifer may be occurring locally in the vicinity of the Kitchener-Waterloo-Bridgeport complex. This would indicate that future development of the overburden aquifers may be more costly than past development and may result in decreased streamflow.

It appears that an alternate water supply will be required for the Kitchener-Waterloo-Bridgeport complex in the near future, whereas the Galt, Guelph, Hespeler, Preston and Paris areas are expected to need an alternate source by 1986. Sufficient ground water appears to be available for the remaining municipalities for the foreseeable future. To efficiently utilize the ground-water resources until an alternate source of water is available, bordering municipalities could employ joint exploration and well development programmes. Interconnection of bordering distribution systems would also be beneficial to the participating municipalities.

The use of surface waters in the study area for domestic purposes is not considered to be practical. Virtually all of the water presently available will be required for dilution of the treated effluent from the water pollution control plants in the area. A detailed study of waste disposal practices in the

Grand River Watershed is required to ascertain if an improved degree of treatment is necessary or whether flow augmentation through water storage reservoirs would be a more practical means of maintaining satisfactory water quality.

All of the Great Lakes are suitable as raw water sources. These waters are only one quarter as hard as the ground waters in the region and do not have appreciable quantities of iron present. The relative distances of each from the study area, from near to far, are Lake Ontario, Lake Erie and Lake Huron or Georgian Bay with the approximate distances being 40, 60 and 75 miles respectively. However, Lake Ontario is approximately 325 feet lower in elevation than the other lakes.

The report previously prepared by James F. MacLaren Limited, Consulting Engineers, on "Regional Water Supply in the Lower Grand Valley for the Ontario Water Resources Commission" was utilized in considering various aspects of water supply for the Middle Grand River Region.

Two alternatives appear feasible for the supply of good quality surface water to this region. Since only the Kitchener-Waterloo-Bridgeport complex requires additional water in the near future, enlargement and extension of the proposed Lower Grand Valley Water Supply System appears to be the most practical scheme to satisfy the immediate needs in these communities. A second system utilizing Lake Ontario could be built by 1986 to serve the remaining large municipalities and to supplement the Lake Erie system. If <u>all</u> of the municipalities within the Galt-Guelph-Kitchener triangle desired surface waters <u>now</u>, a system employing Lake Ontario waters would be practical. A separate system as outlined in the MacLaren report would be required for the Lower Grand Valley municipalities.

Ultimately, interconnections between the proposed Middle Grand River Water Supply System and the Lake Huron Water Supply System or the proposed Southern Peel County Area Water Supply System or both might be possible.

RECOMMENDATIONS

General

1. All of the municipalities should continue to develop ground-water supplies to meet their needs until at least 1971 as it would be impractical to provide an alternate supply before that time.

2. All of the municipalities should provide adequate water storage facilities based on the standard requirements as outlined.

3. A study of the pollution control facilities that will be required in the future in the Grand River Basin should be undertaken.

Specific

1. The Towns of Elmira, Fergus and New Hamburg, and the Villages of Ayr, Elora and Wellesley should continue to develop and utilize ground-water supplies for the future.

2. Joint exploration and development programmes of ground-water sources should be undertaken by the Cities of Kitchener and Waterloo until an alternate water supply is available. Integration of the water distribution systems would also be desirable. It is assumed that the City of Kitchener will continue to supply the Village of Bridgeport.

3. The City of Galt and the Town of Preston should consider the advantages of uniting their water distribution systems and jointly undertaking ground-water exploration and development programmes to serve their common needs until a surface-water

supply is available.

4. If <u>all</u> of the major Middle Grand River Region municipalities wish to participate in the provision of a surface-water supply at this time, a Lake Ontario oriented system should be developed. A separate system, utilizing Lake Erie, should be developed for the Lower Grand Valley municipalities.

5. The Lower Grand Valley Regional Water Supply System should be enlarged and extended to serve the Kitchener-Waterloo-Bridgeport complex as soon as possible, and Paris when required, if it should develop that the other municipalities in the region are not in favour of the system outlined in Recommendation No. 4 at this time.

6. Thereafter, a Lake Ontario system should be developed when required to serve Galt, Guelph, Hespeler and Preston and to provide additional water for the Kitchener-Waterloo-Bridgeport complex. It is expected that this second system will be required by 1986.

III

GENERAL

DESCRIPTION OF STUDY AREA

Boundaries

On the west, the boundary of the County of Waterloo forms the limit of the study area. To the north and east, the County boundary was extended to include the entire Townships of Pilkington, Nichol, Guelph and Puslinch. In the south, the Township of South Dumfries was added.

The study area contains 24 municipalities. These are as follows.

Cities

Galt
Guelph
Kitchener
Waterloo

Towns

Elmira
Fergus
Hespeler
New Hamburg
Paris
Preston

Villages

Ayr
Bridgeport
Elora
Wellesley

Townships

Dumfries North
Dumfries South
Guelph
Nichol
Pilkington
Puslinch
Waterloo
Wellesley
Wilmot
Woolwich

Topography

The main physiographic features of the region are the drumlinized till plain which surrounds Guelph and extends over a large part of the area to the north and east; the morainic hills which predominate in the south-east; the Waterloo Sandy Hills which lie to the west of the Kitchener-Waterloo area; the Oxford Till Plain to the west of the sandy hills and the northern hills and plains which cover the north-west part of the region.

These characteristics provide the most interesting topographic relief in the entire watershed.

The elevation of the region rises from 800 feet on the southern morainic region to 1,425 feet in the Waterloo Sandy Hills. In comparison, the elevation of the entire watershed ranges from 570 feet at Lake Erie to 1,725 feet at the northern extremity.

The nature of the soil in the area varies from clay loam through loam to sandy loam from north to south in the study area. These surface soils are underlain by sand and gravel, till or lacustrine sediments of varying texture.

Drainage

The entire region lies within the Grand River Watershed with the exception of the south-east corner of the Township of Puslinch which is drained by small streams flowing south-east to Lake Ontario.

The total drainage area of the Grand River is 2,614 square miles. The study region encompasses 828 square miles. The Nith, Conestogo, Speed and Eramosa Rivers which are the major tributaries of the Grand River, all flow through the study area.

To date three storage reservoirs have been constructed on the Grand River. These are Belwood Lake, impounded by the Shand Dam constructed in 1942; Luther Lake impounded by the Luther Marsh Dam (1954) and Conestogo Lake impounded by the Glen Allan Dam (1959). Further reservoirs have been planned on the river and its tributaries at West Montrose, Ayr, Everton, Guelph, Hespeler and Laurel Creek. Dam sites have also been investigated at Harrisburg, Nithburg, Vandecar, Princeton, Colles Lake and Arkell.

Climate

Generally the climate in the region consists of moderate winters and warm summers with adequate precipitation throughout the year. The mean annual temperature is approximately 44° Fahrenheit with summer and winter temperatures averaging 66° and 22° respectively.

The average precipitation, which is fairly uniform throughout the year, is 34 inches, with snowfall being approximately 65 inches in the middle region of the watershed. Of interest is the fact that these climatic conditions are favourable for the growth of algae in surface waters, as is the case in most of Southern Ontario.

POPULATION

Population projections can be made in various ways and are subject to many methods and opinions. The factors affecting a growth area such as this, are numerous and variable.

In any region certain factors become critical and may be limiting. In the study area, it is probable that the more critical needs include the provision of an adequate supply of high quality water, the removal of waste disposal problems and the construction of more north-south trending means of transportation. The latter need is presently under study and waste disposal problems will be reviewed at a later date. Table III-1 was developed by staff of the Ontario Water Resources Commission. It was assumed that the conditions of all limiting-growth factors have been met. Past growth rates in the various municipalities were considered, and discussions were held with local, county and provincial planning representatives. It was assumed that municipal boundaries are flexible and in future may not be as they exist today.

LAND USE

Figure III-1 outlines the areas in which urban development

is expected to occur. This plan was developed by Commission staff subsequent to discussions with local and county planning officials. An attempt has been made to depict the areas which would be most suitable for development considering all of the many planning concepts.

No effort has been made to apportion the area according to specific land use, such as residential, industrial, commercial, open space, institutional, transportation and utilities, and agricultural. However, it is probable that the majority of the land in the study region will remain essentially for agricultural purposes.

The majority of the area municipalities have or are preparing an official plan, or appropriate land use control by-laws. In addition, planning boards in the Counties of Brant and Waterloo have recently been created. These should assist in providing adequate control over urban sprawl.

TABLE III-1

PRESENT AND PROJECTED FUTURE MUNICIPAL EQUIVALENT POPULATIONS

Municipality	1965 Assessed Population	1971	1976	1986	Ultimate
URBAN					
Cities					
Galt	31,637	38,300	44,800	61,600	150,000
Guelph	48,035	58,100	68,100	93,600	200,000
Kitchener	86,616	104,800	122,800	168,900	400,000
Waterloo	27,953	33,800	39,600	54,500	125,000
Sub-Total	194,241	215,000	275,300	378,600	875,000
Towns					
Elmira	3,887	4,700	5,500	7,000	15,000
Fergus	4,336	5,000	5,700	7,300	15,000
Hespeler	5,155	6,000	6,800	8,600	15,000
New Hamburg	2,350	2,700	3,100	3,900	10,000
Paris	6,115	6,600	7,000	8,000	12,000
Preston	12,500	15,100	17,700	24,400	60,000
Sub-Total	34,343	40,100	45,800	59,200	127,000
Villages					
Ayr	1,092	1,300	1,550	2,100	5,000
Bridgeport	1,993	2,400	2,800	3,900	10,000
Elora	1,549	1,900	2,200	3,000	7,500
Wellesley	661	800	950	1,300	3,000
Sub-Total	5,295	6,400	7,500	10,300	25,500
RURAL					
Townships					
N. Dumfries	3,626	3,800	4,000	4,500	5,900
S. Dumfries	3,477	3,700	3,900	4,300	5,700
Guelph	5,594	5,900	6,200	6,900	9,200
Nichol	1,985	2,100	2,200	2,400	3,300
Pilkington	1,270	1,300	1,400	1,600	2,100
Puslinch	3,008	3,200	3,400	3,700	4,900
Waterloo	9,425	10,000	10,500	11,700	15,500
Wellesley	4,884	5,200	5,400	6,000	8,000
Wilmot	6,016	6,400	6,700	7,400	9,900
Woolwich	5,915	6,300	6,600	7,300	9,700
Sub-Total	45,200	47,900	50,300	55,800	74,200
TOTAL	279,079	309,400	378,900	503,900	1,101,700

IV

WATER RESOURCES

AVAILABILITY

Surface Water

Description of Streams

The Grand River drainage basin occupies the central part of the Southern Ontario peninsula bounded by Lake Huron, Lake Erie, and Lake Ontario. The river rises near Dundalk, flows essentially in a southerly direction, and drains into Lake Erie below the Town of Dunnville. Physical properties of all watercourses within the area of study are shown in Table IV-1. Detailed descriptions of all pertinent streams and watersheds can be found in the Grand River Conservation Report, (Hydraulics), 1962. The characteristics of the upstream portions of the watercourses are also included in Table IV-1 as they influence the downstream study area.

To facilitate the analysis of natural drainage characteristics, the boundary of the study area has been established to follow natural drainage boundaries as shown on Figure IV-1. The Grand River enters the study area about one mile north of Fergus. The other streams flowing into the study area are the Conestogo River at Glen Allan, the Nith River near Wellesley, the Speed River at Armstrong Mills, the Eramosa River at Rockwood, and Irvine Creek near Belwood. All streams which were considered, except Fairchild Creek, join the Grand River within the study area. Fairchild Creek which originates in the study area, joins the Grand River south of Brantford. Consequently, apart from sub-surface flow, water leaves the study area at only two points; the Grand River north-west of Brantford, and Fairchild Creek north-east of Brantford.

Directly above the study area, two dams are operated by the Grand River Conservation Authority to regulate flow. These are the Shand Dam (Belwood Lake) on the Grand River north of Fergus, completed in 1942, and Glen Allan Dam (Conestogo Lake) on the Conestogo River, completed in 1959. Luther Dam, located about 10 miles north of the study area and operated since 1954, has a further effect on the flow in the Grand River. In addition to these major dams, there are many small dams and weirs on streams in the area. These small dams are used to increase water depths to create mill ponds and for recreation and aesthetic purposes, but seldom for streamflow maintenance.

Grand River Conservation Authority

The Grand River Conservation Authority was established April 6, 1966, uniting the Grand Valley Conservation Authority established in 1948 and the Grand River Conservation Commission established in 1938. It has jurisdiction over the entire drainage basin of the Grand River.

Table IV-2 shows the reservoirs constructed, proposed or under study within the Grand River Basin lying either above or in the Middle Grand River Region and summarizes estimated capacities, status of projects and indicated uses of the reservoirs.

Streamflows

The Department of Mines and Technical Surveys, Water Resources Branch, operates automatic streamflow recording stations on most of the important watercourses in the Middle Grand River Region. The records from these stations were used to evaluate the flow sustained in rivers and streams. Table IV-3 list the stations, their drainage areas, years of continuous record, mean annual flows, and seven-day minimum flows. The locations of these gauges are shown on Figure IV-1.

In December 1964, the gauges on the Grand River at Waldemar and above Lake Belwood, $2GA_{22}$ and $2GA_{27}$ were replaced by gauge $2GA_{14}$. One year of records is available for this gauge. Gauge $2GA_{13}$ on the Conestogo River was discontinued in 1958, just before completion of Glen Allan Dam. Since flow in the Conestogo River is now regulated, present-day records for this location would differ considerably from those available. The manual type gauge ($2GA_{18}$) on the Nith River at New Hamburg was replaced by an automatic recording gauge in August 1965. Gauge $2GA_{21}$ on Lutteral Creek has been affected frequently by beaver dams and was therefore discontinued in September 1965. A new gauge was installed about 2 miles downstream in June 1966. The Speed River above Guelph is in much the same condition today as in 1961, when gauge $2GA_{20}$ was removed. Therefore the flow records available for this station can be assumed to be representative of today's conditions.

Two new automatic gauges were installed in 1965 and will furnish further data in coming years. Since the flow in Alder Creek, a tributary of the Nith River may be affected by heavy pumping from a number of Kitchener municipal wells, station $2GA_{30}$ was established on this creek, about 2 miles north of New Dundee. Another new station, $2GA_{31}$, is located on Blue Springs Creek, a tributary of the Eramosa River, about 2 miles east of Eden Mills.

For the purpose of estimating ground-water runoff, that is, the portion of streamflow contributed through the ground, the following procedure was used. For each of the stations listed on Table IV-3, excepting $2GA_{27}$, $2GA_{28}$ and $2GA_{16}$, a number (two to four) of representative water years were selected on the basis of annual precipitation, annual discharge, and minimum flow. Streamflow hydrographs were drawn for the years selected. Corresponding hydrographs of ground-water runoff were then drawn

on the basis of the available data. At gauging stations affected by regulation, flow was divided into regulated flow, natural ground-water runoff, and natural surface runoff. At the stations situated directly below Shand Dam (Belwood Lake) and Glen Allan Dam (Conestogo Lake) natural ground-water runoff was assumed to be similar to that at the nearest station above the dam, and adjusted for the larger drainage area.

Seven-Day Minimum Flows

The seven-day minimum flow in a particular water year, and for a certain point on a stream is defined as the arithmetic mean of the lowest flows occurring in a period of seven consecutive days as recorded for that year and that station. For any station, seven-day minimum flows may be averaged over all years of record to obtain a mean seven-day minimum flow. Maximum, minimum, and mean seven-day flows for all streams equipped with automatic gauging stations are listed on Table IV-3.

It was found that for most streams, effluent flow discharged by water pollution control plants and industries located above gauging stations did not exceed 10 per cent of the mean seven-day minimum flow at the station. Therefore, effluent flow was not considered to be significant and was not used to adjust streamflow except for streams mentioned specifically. Cooling water returned to the stream was not regarded as an effluent.

Mean seven-day minimum flows in small streams with flows of 5 cfs or less, and not equipped with flow gauges were estimated by relating flow measurements taken during the summer months of 1966 to the mean seven-day minimum flow in a nearby stream for which flow records were available. Generally, only streams with watersheds of similar size and similar geography were compared. For larger streams and rivers, full ranges of mean seven-day

minimum flows were estimated both by this method and by proportioning minimum flows according to drainage area. Continuous ranges of mean seven-day minimum flows are given on Figure IV-1.

At most gauging stations, maximum and minimum values of the seven-day minimum flow vary considerably from the mean. Variations are most severe at stations located in the upper reaches of a stream. Comparison of a list of seven-day minimum flows with meteorological data shows that a year of abnormally high or low precipitation generally results in abnormally high or low seven-day minimum flows. Since the periods of record are dissimilar for all gauging stations in the area, the figures given in Table IV-3 should be treated with some caution. For a stream with a short period of record, a single abnormal year may distort the minimum flow characteristics significantly.

Regulation in the Grand and Conestogo Rivers is reflected in high seven-day minimum flows in the Grand River as it passes through the study area. The Conestogo River has been subject to regulation by Glen Allan Dam since 1959. Flow records for the Conestogo River at Conestogo are available for the years up to 1958 only, hence these are not representative of present conditions. For this station, values for present-day mean seven-day minimum flows have been estimated and are shown below the pre-1959 values in Table IV-3.

Cooling water discharged into the Canagagigue Creek at Elmira was estimated to be 1.1 cfs at the present time. Since most of this water is taken from wells, it is possible that none of it would have naturally reached the stream. For this reason, the flow of cooling water has been subtracted from the seven-day minimum flow. The net values are given in Table IV-3.

Seven-day minimum flows in the Speed River below Guelph, and the Eramosa River, are likely affected by ground water withdrawn from the banks of the Eramosa River by the City of Guelph. Ground water is intercepted by spring collection systems before it can reach the river in the form of ground-water runoff. Since gauge $2GA_{29}$ is below the spring system, the flow measured may be abnormally low. Below Guelph, the Speed River contains a considerable amount of effluent. Most of it is discharged from the Guelph Water Pollution Control Plant, which is located downstream of gauge $2GA_{15}$ and is therefore not included in the flow measured at that station. Mean effluent discharge is approximately 9 cfs.

As minimum flows in a stream depend heavily on geology, topography and plant cover of the watershed, it is impossible to establish a simple relationship between drainage area and seven-day minimum. However, in general, for a drainage basin in the Middle Grand River Region consisting of approximately equal parts of till and sand, it may be expected to produce a seven-day minimum flow of about 0.03 cfs per square mile. Deviation from this general average is shown in the table below.

	Drainage Area (sq.mi.)	7-Day Min. Flow (cfs)	7-Day Min. Flow (cfs/sq.mi.)
Irvine Creek	80	1.5	0.02
Cedar Creek	24	5.0	0.21
Blue Springs Creek	29	5.0	0.17

Both Cedar Creek and Blue Springs Creek have exceptionally high flows during the summer months.

Ground Water

General

The following section on ground water includes a description of the distribution and gross hydrogeologic characteristics of the

main ground-water aquifers and estimates of the ground-water recharge and availability.

The section contains statistics and statements that have been extracted from reports on previous studies which are not supported by data included in this report. However, they are considered valid on the basis of data presented in the earlier reports.

Description of Aquifers

The term aquifer is used to describe a saturated, water-bearing zone or formation in the rock or overburden that has the ability to transmit water.

Bedrock Aquifers

The geologic boundaries of the different bedrock formations, as interpreted by B. Sandford of the Geological Survey of Canada, are shown on Figure IV-2.

Dolomite of the Guelph-Lockport formation of Silurian age underlies the overburden in the eastern half of the study area. Wherever it occurs immediately beneath the drift it constitutes a potential aquifer. The Guelph-Lockport formation consists of thin-bedded to massive, grey to white dolomite. Reefal structures consisting of porous, non-bedded, white to bluish-grey dolomite are common. Occurrences of shale and gypsum interbedded with dolomite are known to be present locally near the western boundary of the Guelph-Lockport bedrock surface.

The Salina formation lies to the west and above the Guelph-Lockport formation. It also constitutes a major ground-water aquifer; however, the formation, which consists chiefly of inter-bedded dolomite and shale, has wide-spread occurrences of gypsum or anhydrite which cause the ground water to be strongly mineralized.

The permeability in the Salina formation seems to be mainly the result of fracturing and the removal of evaporites in solution.

The water-bearing zones in both the Salina and the Guelph-Lockport formations may occur at any depth if the formations are considered regionally but are found at fairly constant horizons locally.

There appears to be relatively good lateral hydraulic connection between bedrock wells but the vertical hydraulic connection between water-bearing horizons is often quite poor. The bedrock is hydraulically connected with overlying overburden aquifers in some areas. In the vicinity of the major streams there is an apparent upward movement of water from the bedrock to the overburden aquifers. Within these areas the overburden may yield water of poor chemical quality. Some of these areas are shown on Figure IV-2.

The Bass Island and Bois Blanc formations which overlie the Salina formation in the western part of the study area may also yield relatively large supplies of water locally, but regionally they are less productive than the Guelph-Lockport and Salina formations. The Bass Island formation is a thick-bedded to massive, light brown to buff dolomite with fracture-type porosity. The Bois Blanc formation is composed of bedded limestone, dolomite and chert with minor sandstone. The porosity may be of the intergranular, bedding, or fracture type.

Yields from Bedrock Aquifers

Both the Guelph-Lockport and Salina formations may yield large amounts of water to drilled wells. The largest yields seem to be found in areas where reefal structures occur, where large solution channels have been developed or where thick sections of the formations, with several water-bearing horizons,

are present. The most productive areas to date have been found in the Guelph-Lockport formations in the vicinity of Galt and Guelph and in the area between and in the Salina formation in the vicinity of the Grand River near Paris, Kitchener and Bridgeport.

The yields from wells drilled through a full section of the Guelph-Lockport formations generally vary from 200 to 2,000 gpm; however, high capacity wells cannot be obtained at all sites tested. The number of wells drilled for municipal purposes that yield in excess of 400 gpm is greater than the number yielding less than 200 gpm in the vicinity of Galt, Hespeler and Guelph. A number of wells yielding between 300 and 1,200 gpm have been drilled in the Salina formation but the wells usually have hard water with a high sulphate content. The quality of the water from the different aquifers is discussed in more detail later in the report.

The yields from wells drilled into the upper half of the Salina, Bass Island and Bois Blanc formations are usually less than 300 gpm and in many areas are less than 100 gpm.

The thickness of the section of bedrock that may yield potable water varies greatly from place to place but is generally greatest in the Galt to Guelph area. The top few tens of feet of the rock appear to be most productive but this rule does not hold everywhere. Some of the highest capacity wells at Galt and Guelph obtain most of their water from horizons more than 100 feet below the bedrock surface.

Overburden Aquifers

The surficial or overburden aquifers are the saturated, relatively clean, coarse-textured deposits of sand and gravel which occur erratically throughout the overburden.

The clayey tills within the study area are commonly fine grained and poorly sorted and have insufficient permeability to be

considered as aquifers. The silty and sandy tills that are closely associated with coarse-textured outwash material may be moderately permeable, and these in combination with small lenses of sand and gravel within them provide limited quantities of water to dug and bored wells and in many instances to drilled wells. The supply of water from such wells is adequate for private supplies but inadequate for municipal purposes.

The occurrence of overburden aquifers is extremely irregular, and their character and distribution vary widely. The geology of the surficial deposits provides a basis for the general determination and delineation of these aquifers.

Grouping the overburden aquifers into surface, interbedded and basal is convenient for descriptive purposes and recognizes certain common characteristics of the aquifers comprising each group.

The surface overburden aquifers occur just below the land surface and are usually composed of outwash sand and gravel. The water in these aquifers is under water-table conditions, and the permeability of the deposits is often high. The saturated thickness of such aquifers is often not more than a few feet to a few tens of feet. Where the aquifers are extensive and thick, large amounts of water can be obtained. Large areas of outwash and kame deposits are present within the drainage basin of the Middle Grand River.

The interbedded overburden aquifers are deposits of sand and gravel that occur either as sheet-like deposits with considerable lateral extent or as lenticular and discontinuous deposits distributed erratically throughout the glacial drift. They are commonly separated from the surficial aquifers and from the bedrock by layers of glacial till. The water in the interbedded aquifers is usually under artesian pressure. Interbedded

aquifers, which may be remnants of relatively coarse-textured outwash and kame deposits, are extensive in the study area and constitute the most productive source of water supply from the overburden at the present time.

The basal overburden aquifers are deposits of sand and gravel that occur at the base of the overburden immediately above the bedrock. Material in the basal aquifer may in places be coarse textured with a relatively high permeability. The thickness of the basal aquifer may vary quickly locally. Small patches of basal aquifer are common within the study area. A quite extensive basal aquifer is present in the vicinity of Blair and Doon, and appears to extend northward through Bridgeport and Conestogo to Elmira. Where the basal overburden aquifer overlies the permeable Salina bedrock, the bedrock and basal overburden aquifers appear to be hydraulically connected and yield water of similarly poor chemical quality.

The limitations of geologic and hydrologic data permit only a generalized interpretation of the occurrence and distribution of overburden aquifers. Additional data are necessary before the overburden aquifers can be accurately defined and their potential evaluated precisely. The total thickness of water-bearing sand and gravel varies from a few feet to more than 150 feet. The degree of interconnection between aquifers is not established in most areas. For the above reasons the most important overburden aquifers have been mapped for this report as a unit. Such a procedure, although an over-simplification, serves to show a gross approximation of the extent of readily mappable aquifer materials. The region outlined as overburden aquifer encompasses the area where upwards of 10 feet of water-bearing sand and gravel have been reported or are indicated by

the surficial geology. Over a large portion of the area, the aquifer mapped is either of the interbedded or basal type. Good overburden aquifers may be present in a number of areas beyond those shown, but they could not be delineated during the preparation of this report.

It is important that the entire area mapped as aquifer not be considered as an area suitable for the construction of high capacity wells; however, it may be possible to influence hydraulically and thus obtain recharge from much of the area by suitably located wells.

Recharge and Availability

The recharge to the aquifers in the study area comes originally from precipitation. The percentage of the precipitation that actually enters and later leaves the aquifers is dependent upon the precipitation pattern, the infiltration capacity of the overburden materials above the aquifers, the hydraulic gradient, and the rates at which water is removed artificially or drains naturally from the aquifers. The ground water that drains or flows naturally from the aquifer and non-aquifer sections of the overburden and bedrock to surface streams, makes up the ground-water runoff or base flow. By calculating the amount of ground-water runoff in a given stream it is possible to get a fair approximation of the amount of ground-water recharge in that drainage basin. The ground-water runoff for different streams varies considerably. Within the study area the range has been calculated to be from 0.078 to 0.225 million gallons per day per square mile.

The accurate determination of ground-water runoff is normally difficult to achieve. The method employed in this study is discussed briefly under the section on "Streamflow". The base

flow to the Grand River, as estimated from data obtained from gauge $2GB_1$ at Brantford which measures total flow from the entire study area, correlates well with the total of the base flows calculated for the various individual streams above gauge $2GB_1$. This indicates consistency in the method used to separate the hydrographs into surface runoff and ground-water runoff; however, it does not necessarily indicate that the ratio of ground-water flow to total flow is correct.

In an effort to determine what influence the different types of surficial deposits have on infiltration the base flows to the different streams were plotted against the percentage by area of clay and till found within individual drainage basins. The plot showed no clear relationship. In fact, some basins, where the surface deposits consisted of 55 to 65 per cent till, had larger base flows than some where the amount of till was less than 35 per cent. The absence of any clear relationship illustrates the complexity of hydrologic factors affecting runoff. The overburden aquifer outlined on Figure IV-2 is overlain by till over 32 per cent of the area and by outwash and kame moraine deposits over 68 per cent of the area.

Recharge to the bedrock aquifers is derived chiefly from leakage through the glacial drift and is dependent originally upon precipitation. No attempt was made to determine accurately the amount of leakage.

For the purpose of this study it was decided to equate recharge to ground-water runoff. To this should be added the amount of water withdrawn by wells and not returned to the streams whose base flows were used for the estimation of recharge. As the amounts consumed could not be determined no adjustment was made.

Adequately constructed and suitably spaced wells located where an aquifer is thick and extensive may extend a cone of influence beyond the limits of the aquifer and thus capture recharge from an area more extensive than the aquifer itself.

Studies carried out by the Illinois State Water Survey and the Illinois State Geological Survey in an area geologically and hydrologically similar to south-western Ontario have established that of the precipitation that enters the ground and becomes ground water approximately 58 per cent may be recovered by wells. To be conservative, a value of 50 per cent of the estimated rate of ground-water runoff or recharge has been used to estimate ground water available for withdrawal from wells in the Middle Grand River Region. Calculations of these factors are summarized below.

Summary of Ground-Water Recharge and Availability

Description of Area and Aquifer	Area (Square Miles)	Estimated Recharge Rate (mgd/ sq. mile)	Estimated Ground-Water Recharge (mgd)	Estimated Ground-Water Available* (mgd)
Total Area	1,126	0.170**	190	95
Guelph-Lockport aquifer not overlain by mapped overburden aquifer	463	0.170	78	39
Mapped overburden aquifer	211	0.170	36	18
Area excluding mapped overburden aquifer and Guelph-Lockport aquifer	452	0.170	76	38

* - The estimated ground water available for development is 50 per cent of the total recharge. Pumpage data from existing municipal well fields indicate that in excess of 50 per cent of total recharge can be and is developed in some areas where the aquifer is extensive.

**- This figure of 0.170 mgd is equal to the average ground-water runoff for the entire study area calculated from the flow measured by gauging station $2GB_1$ at Brantford. It is also equivalent to the average ground-water runoff calculated for the area drained by the Nith, Speed and Conestogo Rivers.

The estimates show that theoretically about 95 mgd of ground water are available for withdrawal; however, because of aquifer conditions only 57 mgd of good quality water is estimated to be available for municipal purposes. An additional 38 mgd may be available for withdrawal but because of aquifer conditions and water quality it is doubtful that much of it may be developed for municipal purposes.

QUALITY

Surface Water

The quality of the surface waters of the Grand River and its tributaries is outlined in Table IV-4. The analyses reported may be divided into three classifications. The sanitary chemical analyses, which include the coliform count, biochemical oxygen demand and total and suspended solids, are a measure of the level of pollution in the water. The general chemical analyses including hardness, alkalinity, chlorides, iron, pH, phenols, colour and turbidity, indicate the suitability of a water for use as a source of domestic water supply. The nitrate and phosphate concentrations are a measure of the fertility of the water. Fertile waters are often not suitable for use as sources of water for potable purposes as nuisance conditions such as weed and algae growths may arise. These nuisance conditions are often connected with offensive tastes and odours in water supplies.

The objectives for sanitary quality in the Province's surface waters are as follows.

M.F. Coliform Count - logarithmic average
not greater than 2,400 per 100 ml

5-Day BOD - not greater than 4 ppm

In reviewing Table IV-4, it can be seen that the water of the Grand River and its tributaries is generally acceptable in this

respect. The sampling stations at which exceptions are evident are below Galt (G-86.5), at Preston (G-94.3), below Hespeler (GS-96.6), below Guelph (GSP-105.2) and below Elmira (GCG-125.6). It should be realized that increasing development in the region could result in further deterioration of the water quality.

With respect to the general chemical quality of the surface water in the region the following facts are pertinent.

Hardness - No specific limit is usually placed on hardness although it is suggested that waters for domestic use should contain less than 250 ppm hardness as $CaCO_3$. The degrees of hardness are indicated as:

Soft	-	0 - 60 ppm as $CaCO_3$
Moderately Hard	-	60 - 120 ppm as $CaCO_3$
Hard	-	120 - 180 ppm as $CaCO_3$
Very Hard	-	greater than 180 ppm as $CaCO_3$

Alkalinity - Alkalinity of natural waters is due to the presence of salts of weak acids usually bicarbonates. The concentration is reported in ppm of $CaCO_3$ and is significant in determining aggressive tendencies and softening treatment requirements.

Chlorides - Chlorides are naturally present in varying concentrations in water supplies. Increasing chloride concentrations may indicate contamination from domestic sewage.

The recommended maximum concentration to avoid saline tastes is 250 ppm.

Iron - The recommended maximum limit for iron is 0.30 ppm. Concentrations in excess of 0.30 ppm are not harmful but have objectionable staining and sediment-forming properties. Concentrations in excess of 1.00 ppm may cause metallic tastes.

pH - is the measure of the hydrogen ion concentration in water. A value of 7 indicates a neutral water with higher values indicating basic properties and lower, acidic properties. The suggested range for surface waters is 6.7 to 8.5.

Colour - Colour in natural water may result from contact with organic matter or chemical substances.

Turbidity - Turbidity is caused by the presence of suspended matter such as clay, silt, finely divided organic matter, plankton and other microscopic organisms in water. It is an expression of the optical property of a sample and is measured in units.

Phenols - Phenols react with chlorine to produce intensely aromatic compounds which result in tastes and odours in water. They are associated with many industrial wastes and are not present in natural water. The objectives for surface waters in the Province are:

Average phenol content - not greater than 2 ppb
Maximum phenol content - not greater than 5 ppb

The analyses results listed in Table IV-4 indicate that the water is very hard and contains iron in excess of the recommended maximum concentration of 0.30 ppm. In addition, phenol concentrations are sometimes evident at several of the points sampled.

The Grand River and its tributaries, like many of the rivers and streams in Southern Ontario may be classified as fertile. It has been suggested that if the phosphorous content of a surface water is 0.015 ppm or greater, and the nitrogen content is 0.300 ppm or greater, algae growths can be expected. The levels of these nutrients at the points sampled were generally above these concentrations. Nuisance conditions such as excessive algae and aquatic weed growths which might restrict the use of the rivers and streams in the region for water supply purposes can be expected. This could be especially true in impoundment reservoirs where low velocities would provide an excellent opportunity for these growths to occur.

For comparison, the following table outlines the quality of the water in Lakes Erie, Huron and Ontario and also in Georgian Bay.

Great Lakes Water Quality

	Lake Erie Peacock Point	Lake Huron Grand Bend	Lake Ontario Burlington	Georgian Bay Collingwood
Hardness as $CaCO_3$ (ppm)	135	100	137	94
Alkalinity as $CaCO_3$ (ppm)	102	86	98	78
Chlorides as Cl (ppm)	24	6	26	6
Iron as Fe (ppm)	0.40	0.25	0.10	0.14
pH at OWRC Lab.	8.0	8.3	8.1	8.0
Turbidity (Units)	16.7	2.5	2.3	2.3
Colour (Units)	10	<5	<5	<5

This table indicates that these sources are superior to the surface waters of the Grand River Watershed. Lake Huron and Georgian Bay have the best quality water.

Ground Water

The following table indicates the average chemical analyses for water samples from overburden and bedrock aquifers throughout the County of Waterloo and from bedrock wells in the vicinity of Guelph.

Aquifer	No. of Samples Analyzed	Hard- ness (ppm)	Alkal- inity (ppm)	Iron (ppm)	Chlor- ide (ppm)	pH	Sulph- ates (ppm)
Overburden*	54	455	223	1.05	14	7.5	-
Overburden**	42	301	220	0.8	15	7.7	40
Overburden***	12	1,045	236	2.02	7	7.4	729
Guelph-Lockport (bedrock)	21	316	229	0.53	14	7.3	62
Salina (bedrock)	21	808	201	1.24	10	7.6	770
Bass Island & Bois Blanc (bedrock)	11	224	239	0.78	10	7.7	17

* - Average for all samples

** - Average for all samples except those located in areas where the overburden usually yields mineralized water.

*** - Averages from samples in areas where overburden wells usually yield mineralized water.

The Guelph-Lockport aquifer generally yields the best quality ground water in this area with respect to chemical characteristics.

The hardness of the water from the Salina formation varies from 150 to 1,800 ppm. It is usually proportional to the sulphate content when the total hardness exceeds 400 ppm. The water from wells where the hardness is less than 400 ppm usually contains from 40 to 60 ppm of sulphate. Where the hardness exceeds about 400 ppm the water may contain from 60 to over 1,700 ppm of sulphate. Locally the Salina formation may yield up to a few hundred gallons per minute of good quality water, whereas at the same location deeper wells yield very hard water with a high sulphate content. Such appears to be the case in the vicinity of St. Jacobs and Elmira.

The chemical quality of the water from the Guelph-Lockport aquifer is generally better than from the Salina aquifer; however, where water with a low sulphate content can be obtained from the Salina it is likely to be comparable with the water from the Guelph-Lockport aquifer.

The water from the Bass Island and Bois Blanc formations is similar to that from the Guelph-Lockport formation, but locally, may contain various amounts of hydrogen sulphide.

Overburden aquifers usually yield water similar to the better chemical quality water from bedrock aquifers. Locally, overburden aquifers yield mineralized water. This is believed to occur in discharge zones where the overburden and bedrock aquifers are hydraulically connected.

All aquifers within the study area can be expected to yield water with an iron content generally above the recommended maximum of 0.3 ppm. Locally the iron may be either very low or very high.

The ground-water quality is also summarized for each municipality in Table IV-5.

PRESENT UTILIZATION

General

In the Middle Grand River Region, both ground and surface waters are utilized extensively. Wells and springs are sources from which ground water is derived, while rivers, streams, lakes, and natural or man-made ponds are the sources of surface water. No municipality utilizes surface waters for its water supply, except for fire protection. Streams are used primarily for the dilution and assimilation of liquid wastes and as natural outlets for storm drainage. In rural areas, rivers and streams are used for irrigation, livestock watering, recreation and industry. Ground water is the principal source for domestic water supplies in almost all rural areas in the basin. Although adequate supplies of surface water may be available, ground water is preferred because of the better sanitary quality.

Consumption figures were derived from estimates based on populations, actual pumpage records and rates authorized by

water-taking permits issued by the OWRC. It is stressed that all large water users in the area do not necessarily possess a permit and the figures given may not be truly representative of the actual takings.

Rural Domestic Water Consumption

The rural population within the study area, which is estimated to be about 54,740 is scattered throughout the townships. The daily per capita consumption probably varies widely, but an average of 50 gallons has been assumed in this report.

The following table summarizes estimates of rural domestic consumption.

County	Population	Domestic Consumption (mgd)
Brant	5,300	0.27
Halton	800	0.04
Oxford	3,300	0.16
Perth	470	0.02
Waterloo	30,130	1.51
Wellington	11,420	0.57
Wentworth	3,310	0.17
TOTAL	54,740	2.74

Livestock Watering

Water for livestock is derived from both ground and surface sources. Figures for the consumption from each source are not available and the usage will be classified as one.

Consumption figures for the different categories of livestock were taken from Publication 476, Farm Water Supply, Department of Agriculture, while livestock statistics were taken from Publication 20, Agricultural Statistics for Ontario - 1963. Using this set of information and assuming livestock population proportional to the area of the county within the study area, the water usage was calculated as shown:

County	Consumption (mgd)
Brant	0.23
Halton	0.04
Oxford	0.30
Perth	0.06
Waterloo	1.73
Wellington	0.91
Wentworth	0.02
TOTAL	3.29

Irrigation Water Usage

Within the Middle Grand River Basin, 27 permits have been issued to irrigators who expect to extract quantities in excess of 10,000 gallons per day from either ground or surface-water sources. The principal source is surface water, although in certain areas, wells have been developed for irrigation. Irrigation is supplemental to natural precipitation for both crops and golf courses. This use cannot be predicted closely therefore.

(a) Of the above number, 18 permittees utilize the water to irrigate farm lands on which are grown market crops, tobacco and hay, or nursery farms specializing in products such as special types of turf, flowers, seedlings and shrubs.

The permits issued for the above purposes are usually valid for three months of the year - June, July and August. However, the records show that most of the irrigating has taken place during June and July.

The major factors influencing the irrigation demands on any particular day in any area are the available soil moisture for the specific crops grown and their stage of development. These factors in turn are based upon the climatic conditions prevailing in the basin, the soil types and the topography.

The water consumption was estimated on the assumption that on the average only 1/3 of the permitted pump capacity would be utilized at its full capacity for a 12-hour period per day during

the months of June and July as follows:

	CONSUMPTION		
Pump Capacity (gpm)	Surface Water (mgd)	Ground Water (mgd)	Total (mgd)
5567	1.34		
700		0.17	
6267			1.51

(b) Nine permits were issued to golf courses which are valid for the months April to November.

The water used by these permittees was estimated on the assumption that on the average the full pump capacity would be utilized for 8 hours per day throughout May to October as follows:

	CONSUMPTION		
Pump Capacity (gpm)	Surface Water (mgd)	Ground Water (mgd)	Total Water (mgd)
1297	0.62		
100		0.05	
1397			0.67

Recreation

A number of small dams have been built on streams and smaller tributaries to create recreational storage. These dams have little effect on the streamflow distribution as only small quantities of surface water are stored.

Seven permits have been issued for recreational purposes. Six of these derive their supply from surface water sources. The latter permits were granted with special conditions which limit the amount of taking or define when takings may occur, so that adequate normal flow may be maintained downstream of the permittee.

The takings for recreational purposes are comparatively small and have not been included in the total water usage as they would not affect the accuracy of it.

Commercial Water Usage

Although most commercial establishments are located within municipal boundaries and obtain their water supplies from municipal

systems, there are some exceptions. Rural commercial firms depend upon ground water for their supply. Within the Middle Grand River Basin a total of seven permits were issued for withdrawal of water for commercial purposes. The quantity taken is comparatively small. Estimates were made based upon available records of takings. The average pumpage was 0.43 mgd.

Municipal Water Usage

Municipal water usage includes domestic, commercial and industrial use. All municipalities obtain their water from ground-water sources. In this report municipal water usage is subdivided into two groups, industrial and non-industrial. Reference is made mainly to the more significant industrial consumers. Municipal usage figures are shown in Table IV-6. Total usage of water for municipal purposes is estimated to be 25.4 mgd of which about 8.6 mgd is used for major industrial purposes.

Industrial Water Usage

Most of the industries within the study area derive their water supplies from municipal systems. There are some with their own private systems. Figures available for industrial water usage from municipal systems and private sources not governed by permits appear in Table IV-6. In addition, usage under eight permits issued for the extraction of water for industrial purposes is estimated to be 2.12 mgd. All permittees utilize ground-water sources. Total usage for industrial purposes is estimated to be 16.0 mgd of which 8.6 mgd is obtained from municipal sources.

Table IV-7 provides a general summary of the various water usages in each of the counties that lie within the study region.

FUTURE NON-MUNICIPAL WATER USAGE

In the past and at present, ground-water sources have been providing adequate supplies to meet domestic needs. Development

and further improvements in household plumbing and advancing standards of living will require appropriate increases in water demands.

Rural population has had the tendency to remain constant or to decrease slightly during the last decade. As a result ground-water sources should continue to serve domestic requirements adequately in the foreseeable future.

Demands for better quality in farm produce will mean more intensive irrigating programmes. In addition, better sanitation in presenting marketable products will increase farming needs. Therefore, this will put an even greater withdrawal rate upon the streams from which these waters are taken.

Golf courses are among the large users of surface waters. Over the years their number has been increasing and will continue to do so in proportion to population growth.

Recreation demands are very likely to increase; but due to the special conditions under which the waters are withdrawn, it is unlikely that natural streamflows will be greatly affected.

POTENTIAL

General

Precipitation in the region averages 33.6 inches annually, of which only 11.2 inches is discharged as streamflow through the Grand River system. Of the non-accountable water, the major portion is lost to the basin through evaporation and transpiration processes; however, part could be lost in an interchange of ground water between this basin and other basins through deep ground-water percolation.

Only a part of the potential water resources are manageable. It may be assumed that the water that can be developed by means of wells is about 50 per cent of the total ground water available.

The amount of surface runoff that can be captured depends on the number and capacity of reservoirs.

Surface Water

The streams in the Middle Grand River Region show the wide seasonal fluctuations in flow typical of a temperate zone. Pertinent streamflow data are tabulated in Table IV-3. Large quantities of water are discharged during the spring and smaller quantities during the late summer season. The flows in the Grand and Conestogo Rivers are regulated by the operation of a number of upstream dams; however, a wide fluctuation in flow still exists.

Fuller utilization of the surface waters can be achieved through increased storage of the excessive spring flows and their release as required. This would involve a clear allocation of specific reservoir capacities to streamflow maintenance.

The following table shows the effects of future upstream regulation on the flows of the Speed River below Guelph and additional streamflow regulation on the flows of the Grand River at Galt and Brantford. This table is based upon the data provided in Table IV-2, and considers only the reservoir under construction on Laurel Creek, and those reservoirs, which are proposed for early construction and whose secondary use is streamflow augmentation. Furthermore, it assumes that under normal conditions, flood control and streamflow augmentation are compatible uses for these reservoirs. This is not necessarily valid.

Stream	Location	Additional Storage Capacity Above Location (acre-feet)	Mean Increase in Flow During June 1 - March 1 (cfs)
Speed River	below Guelph	15,000	27
Grand River	at Galt	82,200	150
	at Brantford	165,340	302

The streamflow in the Grand River can be further improved through additional reservoirs for flood control, streamflow maintenance and recreation. Other dam sites are being investigated by the Grand River Conservation Authority.

Ground Water

Ground water is generally obtainable for domestic and stock-watering purposes throughout the study area. Where shallow dug and bored wells are inadequate due to increased demands or because of fluctuating ground-water levels within the shallow aquifers, it is usually possible to obtain alternate supplies from greater depth. Highly mineralized water is encountered locally but with rare exceptions ground water has been satisfactory for domestic and stock purposes. There are no large areas within the region where adequate water is difficult to obtain. Deep drilling is required where the topography is rugged, such as areas west of Kitchener and Waterloo, and between Galt and Ayr.

The relative potential for future ground water in the vicinity of each of the major population centres, the potential sources of supply, and remarks pertaining to these sources are as follows:

City of Galt

Potential for Future Development:	Good
Potential Source of Supply:	Overburden aquifer west and south-west of the city; bedrock aquifer immediately west of the Grand River and east and south-west of Galt.
Remarks:	The area immediately east and north-east of Galt is being pumped at near maximum capacity. Future wells will need to be developed farther from the city.

City of Guelph

Potential for Future Development: Good

Potential Source of Supply: Bedrock aquifer in all directions from the city; overburden aquifer in the vicinity of Arkell Springs.

Remarks: All bedrock tests will not be successful but the degree of success should be high. Careful spacing of wells should be practised. Overburden wells above the Arkell Springs would reduce the flow to the spring collector system. Artificial recharge may provide increased supplies from the overburden aquifer in the vicinity of the springs.

City of Kitchener

Potential for Future Development: Fair

Potential Source of Supply: Overburden aquifers south-west of the city and along the Grand River east of Kitchener and Waterloo; bedrock east of the Grand River.

Remarks: The sections of the overburden aquifers presently developed are pumped at, near, or above maximum capacity. New sources of supply will have to be located several miles from the centre of the city.

City of Waterloo

Potential for Future Development: Fair

Potential Source of Supply: Overburden aquifer north-west and west of Waterloo.

Remarks: The quality of the water in the area suggested may not be desirable. Large quantities of high sulphate water are available from the overburden and bedrock north-east of Waterloo.

Town of Elmira

Potential for Future Development: Good

Potential Source of Supply: Overburden aquifer north-west and south-west of the town; top 50 to 80 feet of the bedrock.

Town of Elmira (Cont'd)

Remarks:	Both overburden and bedrock aquifers may yield water with a high iron content. The overburden is likely to be more productive than the upper bedrock aquifer. Except for the top 50 to 80 feet, the water from the bedrock is likely to be mineralized with a high sulphate content.

Town of Fergus

Potential for Future Development:	Good
Potential Source of Supply:	Bedrock aquifer
Remarks:	Systematic spacing of wells should be practised.

Town of Hespeler

Potential for Future Development:	Good
Potential Source of Supply:	Bedrock aquifer north-east of Hespeler.
Remarks:	Small amounts of hydrogen sulphide may be encountered in bedrock wells in the recommended area.

Town of New Hamburg

Potential for Future Development:	Not known
Potential Source of Supply:	Not definite
Remarks:	Insufficient data are available to allow an adequate evaluation of the ground-water potential in the vicinity of the town. There are indications that good quality water may be relatively scarce in the immediate vicinity of the town.

Town of Paris

Potential for Future Development:	Fair
Potential Source of Supply:	Overburden aquifer north-east of Paris both east and west of the Grand River.
Remarks:	The bedrock aquifers in the vicinity of Paris will probably yield mineralized water. Where there is good hydraulic connection with the overburden aquifer, mineralized water may be found in the overburden also.

Town of Preston

Potential for Future Development:	Fair
Potential Source of Supply:	Overburden aquifer north-west of Preston and bedrock aquifers north-east and east of the town.
Remarks:	The ground-water quality west and south-west of the town is relatively poor. Interference with private supplies could be expected if municipal wells were developed immediately north-west of the town. The bedrock well field east of the city is pumped near maximum capacity but could be extended eastward.

Village of Elora

Potential for Future Development:	Good
Potential Source of Supply:	Bedrock aquifer
Remarks:	The water obtained from the municipal wells is very hard with a high sulphate content. Better quality water may be a problem to obtain.

The following table presents a summary of current ground-water usage within the study area and provides data on the amount of water that may be available for future municipal, industrial and rural development. It is stressed again that the availability figures are approximations only and will be subject to modification as further ground-water studies proceed.

Description of Aquifer and Area	Estimated Recoverable Ground Water (mgd)	Estimated Present Ground Water Withdrawal (mgd)	Difference and Amount Available for Development (mgd)
Mapped Overburden Aquifer	18	20	-2*
Guelph-Lockport Bedrock Aquifer	39	15	24
Area Beyond the Mapped Overburden and Guelph-Lockport Aquifers	38	1	37
Total Amount of Ground Water Available for Future Development			59

* - The apparent overdraft of water from the mapped overburden aquifer may be the result of ground-water mining, an underestimate of the amount recoverable or both. As previously mentioned the amount of ground water recoverable from some sections of the aquifer may exceed 50 per cent.

The estimates show that 59 mgd of water appears to be available for future development in the study area. However, 37 mgd probably cannot be developed for municipal purposes because of aquifer conditions or quality. The amount of good quality water potentially available for future municipal development is estimated to be 22 mgd. If the estimates are correct they indicate that there has been effective and full development of the mapped overburden aquifer, and that some mining of ground water may be occurring locally in the vicinity of the Cities of Kitchener and Waterloo. Further development of the overburden aquifers can be expected to be more costly than past development and to be at the expense of streamflow.

TABLE IV-1

PHYSICAL PROPERTIES OF WATERCOURSES

STREAM	UPSTREAM OF STUDY REGION Length (miles)	Mean Gradient (feet per mile)	Drainage Area (sq. miles)	WITHIN STUDY REGION Length (miles)	Mean Gradient (feet per mile)	Drainage Area (sq. miles)
Irvine Creek	10	12.5	37.5	12	14.5	42.5
Canagagigue Creek	-	-	-	12	31.2	56.3
Conestogo River above Glen Allan	26	11.5	221.5	-	-	-
" " Glen Allan to Grand River	-	-	-	21	8.3	98.0
Laurel Creek	-	-	-	12	14.6	29.5
Nith River above Wellesley	15	8.3	145.0	-	-	-
" " " New Hamburg	-	-	-	18	4.2	61.5
" " " Wolverton	-	-	-	34	5.5	157.7
" " " Grand River	-	-	-	56	2.5	68.7
Cox Creek	-	-	-	13	13.5	32.5
Hopewell Creek	-	-	-	9	13.9	28.0
Speed River above Armstrong Mills	12	20.9	66.0	-	-	-
" " Armstrong Mills to Eramosa River	-	-	-	10	16.5	46.8
" " Eramosa River to Grand River	-	-	-	14	9.6	63.0 (a)
Eramosa River above Rockwood	12	27.1	48.7	-	-	-
" " Rockwood to Speed River	-	-	-	12	11.7	60.0

TABLE IV-1
(Cont'd)

PHYSICAL PROPERTIES OF WATERCOURSES

STREAM	UPSTREAM OF STUDY REGION Length (miles)	Mean Gradient (feet per mile)	Drainage Area (sq. miles)	WITHIN STUDY REGION Length (miles)	Mean Gradient (feet per mile)	Drainage Area (sq. miles)
Fisher's Mill Creek	-	-	-	11	13.7	20.7
Galt Creek	-	-	-	17	8.8	38.0
Grand River above Shand Dam	44	8	305.0	-	-	-
" " Shand Dam to Conestogo	-	-	-	22	14.8	73.4 (b)
" " Conestogo to Speed River	-	-	-	24	6.5	78.2 (b)
" " Speed River to Horner Creek	-	-	-	22	8.0	55.6
Fairchild Creek (portion within study area only)	-	-	-	20	15.0	116.0
TOTAL DRAINAGE AREA			823.7			1,126.4

NOTE: (a) Excluding Fisher's Mill Creek

(b) Excluding watersheds previously listed on this table

TABLE IV-2

EXISTING AND PROPOSED RESERVOIRS

ABOVE AND WITHIN THE MIDDLE GRAND RIVER REGION

NAME	STREAM	STATUS	STORAGE CAPACITY ACRE-FEET	STORAGE CAPACITY MILLION GALS.	USES	EXPECTED ORDER OF CONSTRUCTION
Luther Lake	headwater, Grand River	completed in 1954	10,000	2,713	flood control, streamflow maintenance, wildlife sanctuary	
Belwood Lake	Grand River	completed in 1942	49,600	13,458	flood control, streamflow maintenance, recreation	
Conestogo Lake	Conestogo River	completed in 1959	45,060	12,226	flood control, streamflow maintenance, recreation	
Laurel Creek	Laurel Creek	under construction	2,120	575	flood control, streamflow maintenance, recreation	
West Montrose	Grand River	proposed early construction but not yet approved by provincial and/or federal governments (West Montrose, Ayr, Everton, Guelph, Hespeler)	55,790	15,138	flood control, streamflow maintenance, recreation	1
Ayr	Nith River		83,130	22,556	flood control, streamflow maintenance, recreation	4
Everton	Eramosa River		15,000	4,070	flood control, streamflow maintenance, recreation	2
Guelph	Speed River		9,900	2,686	flood control, streamflow maintenance, recreation	3
Hespeler	Speed River		9,300	2,523	flood control, streamflow maintenance, recreation	5
Harrisburg	Fairchild Creek	site investigated	15,000	4,070		
Nithburg	Nith River	site being investigated (awaiting approval by Board of Directors GRCA)				
Arkell	Eramosa River	site investigated (secondary choice)				
Barrie Hill	Speed River	available site (secondary choice)				

TABLE IV-3

SUMMARY OF STREAMFLOW RECORDING STATIONS AND HYDROMETRIC DATA

STATION	LOCATION	Drainage Area (sq. miles)	Water Years of Continuous Record	Mean Annual Flow (a) (cfs)	SEVEN-DAY MINIMUM FLOW Maximum (cfs)	Minimum (cfs)	Mean (cfs)
$2GA_{23}$	Canagagigue Creek near Elmira	44.2	1957 to date	31.2	2.9	0.5	2.1 (b)
$2GA_{17}$	Conestogo River at Drayton	125.0	1950 to date	114.5	7.0	0.2	1.4
$2GA_{28}$	Conestogo River at Glen Allan	222.0	1960 to date	182.0	43.6	2.1	18.1
$2GA_{13}$	Conestogo River near Conestogo	319.0	1946 to 1958	330.0	22.0	5.6	12.6
	Conestogo River near Conestogo	319.0	(c)	279.0	52.0	4.2	22.8
$2GA_{24}$	Laurel Creek at Waterloo	23.0	1960 to date	14.4	1.8	0.1	0.7
$2GA_{18}$	Nith River at New Hamburg	207.0	1951 to date	186.0	29.0	2.7	9.8
$2GA_{10}$	Nith River near Canning	397.0	1948 to date	353.0	84.0	48.0	63.0
$2GA_{21}$	Lutteral Creek near Oustic	21.5	1954 to 1964	20.5	5.5	0.5	1.9
$2GA_{29}$	Eramosa River above Guelph	91.5	1962 to date	63.0	16.5	6.1	11.2
$2GA_{20}$	Speed River above Guelph	106.5	1954 to 1961	90.0	17.4	2.0	6.3
$2GA_{15}$	Speed River below Guelph	228.0	1951 to date	190.0	50.0	10.0	31.0
$2GA_{22}$	Grand River at Waldemar	250.0	1954 to 1964	212.0	14.4	1.3	6.4
$2GA_{27}$	Grand River above Lake Belwood	292.0	1962 to 1964	-	5.1	3.5	4.7
$2GA_{16}$	Grand River below Shand Dam	305.0	1952 to date	242.0	89.9	9.0	42.6
$2GA_{3}$	Grand River at Galt	1,357.0	1914 to date (d)	1,213.0	428.0	115.0	238.0
$2GB_{1}$	Grand River at Brantford	2,010.0	1948 to date	1,770.0	650.0	188.0	425.0

(a) Water Year, a twelve-month period from October 1 to September 30 inclusive
(b) Adjusted for effluent discharge
(c) Estimated flow allowing for effects of dam operation 1958 to date
(d) Records used for period 1943 to date

TABLE IV-4

SURFACE WATER QUALITY

Test	GRAND RIVER ABOVE PARIS G-82.8				GRAND RIVER BELOW GALT G-86.5				GRAND RIVER AT PRESTON G-94.3			
	No. of Samples	Avg.	Max.	Min.	No. of Samples	Avg.	Max.	Min.	No. of Samples	Avg.	Max.	Min.
Coliforms	11	780*	30,000	0	16	1,490*	23,100	10	17	1,570*	130,000	24
BOD	12	3.2	6.0	1.9	18	4.6	9.2	2.0	19	4.4	9.6	1.6
Total Solids	5	354	396	282	12	426	504	292	12	412	512	278
Susp. Solids	5	20	42	11	9	10.6	16	5	10	17	49	7
Turbidity	4	5.7	8.0	0.8	6	4.5	11.0	1.7	6	5.5	10.5	2.0
Phosphorus	5	0.72	0.98	0.60	12	1.05	2.00	0.52	12	0.81	1.30	0.36
Nitrate	5	0.81	1.25	0.22	5	0.84	1.25	0.22	5	0.96	2.50	0.16
Hardness	1	266	-	-	1	264	-	-	1	270	-	-
Alkalinity	1	197	-	-	1	194	-	-	1	196	-	-
Chlorides	4	28	38	21	4	25	32	21	4	21	24	17
Iron	1	2.8	-	-	1	1.7	-	-	1	1.4	-	-
pH	1	7.9	-	-	1	8.0	-	-	1	8.0	-	-
Phenols	-	-	-	-	2	6	12	0	2	12	15	9

TABLE IV-4
(Cont'd)

SURFACE WATER QUALITY

Test	GRAND RIVER AT BRIDGEPORT G-110.3				GRAND RIVER - SHAND DAM G-141.3				CANAGAGIGUE CREEK BELOW ELMIRA GCG-125.6			
	No. of Samples	Avg.	Max.	Min.	No. of Samples	Avg.	Max.	Min.	No. of Samples	Avg.	Max.	Min.
Coliforms	17	1,593*	91,000	20	12	30*	160	0	10	30,000*	1,400,000	1,010
BOD	19	3.0	6.6	1.3	15	2.5	5.8	0.6	9	19.0	122.0	2.0
Total Solids	12	352	436	258	10	295	356	220	3	939	1,896	460
Susp. Solids	10	11.6	28	2	8	10	28	1	2	20	26	15
Turbidity	7	8.9	27.0	1.4	3	4.1	7.0	1.8	2	12.8	20.0	5.5
Phosphorus	12	0.18	0.36	0.06	11	0.09	0.14	0.04	3	0.90	1.28	0.45
Nitrate	5	0.72	1.50	Trace	4	0.20	0.45	Trace	2	0.54	1.00	0.08
Hardness	1	264	-	-	1	260	-	-	-	-	-	-
Alkalinity	1	203	-	-	2	193	198	188	1	241	-	-
Chlorides	4	12.5	16.0	4.0	4	10	13	6	3	40	61	30
Iron	1	1.5	-	-	1	0.58	-	-	-	-	-	-
pH	1	8.2	-	-	2	8.4	8.5	8.2	1	8.5	-	-
Phenols	3	12	18	0	2	13	24	2	4	1,150	4,500	30

TABLE IV-4
(Cont'd)

SURFACE WATER QUALITY

	CONESTOGO R.-OUTLET OF CONESTOGO L. GCO-139.6				NITH RIVER AT PARIS GN-75.3				SMITH CREEK ABOVE WELLESLEY GNS-159.1			
Test	No. of Samples	Avg.	Max.	Min.	No. of Samples	Avg.	Max.	Min.	No. of Samples	Avg.	Max.	Min.
Coliforms	7	25*	900	1	10	1,485*	60,000	220	3	156*	420	90
BOD	8	2.3	3.0	1.4	10	2.3	4.8	0.4	5	2.6	3.6	2.0
Total Solids	4	246	306	202	4	395	508	282	4	282	312	252
Susp. Solids	4	26	58	14	2	36	42	29	5	16	20	15
Turbidity	3	40	53	26	3	8.1	12.5	2.8	3	13.3	20	3.8
Phosphorus	5	0.30	0.60	0.08	4	0.26	0.60	0.10	5	0.23	0.36	0.18
Nitrate	5	0.39	0.50	0.14	4	0.96	2.00	0.24	5	1.09	2.00	0.18
Hardness	1	218	-	-	1	368	-	-	1	260	-	-
Alkalinity	2	178	180	177	1	216	-	-	1	211	-	-
Chlorides	5	9.2	13	4	3	15	17	10	5	13.4	20	10
Iron	1	1.05	-	-	1	0.62	-	-	1	0.82	-	-
pH	2	8.4	8.7	8.2	1	7.8	-	-	2	8.2	8.4	8.0
Phenols	-	-	-	-	-	-	-	-	-	-	-	-

TABLE IV-4
(Cont'd)

SURFACE WATER QUALITY

	SPEED RIVER BELOW HESPELER GS-96.6				SPEED RIVER BELOW GUELPH GSP-105.2				SPEED RIVER ABOVE GUELPH GSP-111.2			
Test	No. of Samples	Avg.	Max.	Min.	No. of Samples	Avg.	Max.	Min.	No. of Samples	Avg.	Max.	Min.
Coliforms	9	23,950*	172,000	220	11	3,362*	170,000	10	4	623*	156,000	0
BOD	8	7.5	10.0	4.2	8	6.0	13.0	1.8	5	3.0	8.3	0.3
Total Solids	4	459	582	350	8	399	440	356	5	318	364	262
Susp. Solids	4	32	66	12	4	21	28	14	-	-	-	-
Turbidity	4	12.0	23	7.5	5	3.1	6.0	1.0	4	3.2	5.0	2.0
Phosphorus	4	1.57	3.80	0.34	-	-	-	-	-	-	-	-
Nitrate	3	0.60	0.75	Trace	-	-	-	-	-	-	-	-
Hardness	1	274	-	-	-	-	-	-	-	-	-	-
Alkalinity	1	207	-	-	-	-	-	-	1	222	-	-
Chlorides	3	38	62	23	-	-	-	-	-	-	-	-
Iron	1	0.96	-	-	-	-	-	-	-	-	-	-
pH	1	7.9	-	-	-	-	-	-	1	8.1	-	-
Phenols	-	-	-	-	-	-	-	-	1	4	-	-

TABLE IV-4
(Cont'd)

SURFACE WATER QUALITY

ERAMOSA RIVER ABOVE GUELPH
GSPE-110.7

Test	No. of Samples	Avg.	Max.	Min.
Coliforms	5	215*	75,000	40
BOD	7	0.8	1.6	0.6
Total Solids	7	285	334	216
Susp. Solids	1	8	-	-
Turbidity	6	5.0	7.0	3.0
Phosphorus	-	-	-	-
Nitrate	-	-	-	-
Hardness	-	-	-	-
Alkalinity	-	-	-	-
Chlorides	-	-	-	-
Iron	-	-	-	-
pH	-	-	-	-
Phenols	-	-	-	-

NOTE: All results reported in ppm with the following exceptions:

Coliforms - number of organisms per 100 ml of sample

* - logarithmic average

Turbidity - units

Phenols - parts per billion

pH - index ranging from 1-acidic, through 7-neutral, to 14-alkaline

TABLE IV-5

MUNICIPAL CHEMICAL WATER QUALITY

Municipality	No. of Samples	Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Iron as Fe (ppm)	Chloride as Cl (ppm)	Fluoride as F (ppm)	pH at Lab.	Sulphate as SO_4 (ppm)
City of Galt	32							
Average		347	252	0.06	16	0.3	7.5	-
Maximum		442	267	0.11	32	0.9	7.6	-
Minimum		268	238	0.04	4	0.0	7.4	-
City of Guelph	44							
Average		356	237	0.17	28	0.3	7.6	-
Maximum		560	290	0.76	170	0.8	8.1	-
Minimum		230	170	0.00	3	0.0	7.2	-
City of Kitchener	78							
Average		358	254	0.29	26	0.1	7.6	-
Maximum		541	326	1.23	200	0.3	7.9	-
Minimum		262	209	0.07	4	Trace	7.3	-
City of Waterloo	16							
Average		648	230	0.62	12	0.3	7.5	-
Maximum		1,640	296	1.32	33	1.0	7.7	-
Minimum		265	183	0.08	4	0.1	7.2	-
Town of Elmira	13							
Average		530	236	0.91	13	0.4	7.5	-
Maximum		534	249	1.70	20	0.4	7.6	-
Minimum		527	221	0.28	6	0.3	7.3	-

TABLE IV-5
(Cont'd)

MUNICIPAL CHEMICAL WATER QUALITY

Municipality	No. of Samples	Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Iron as Fe (ppm)	Chloride as Cl (ppm)	Fluoride as F (ppm)	pH at Lab.	Sulphate as SO_4 (ppm)
Town of Fergus	10							
Average		476	222	0.43	22	0.6	7.6	268
Maximum		560	246	1.74	34	0.7	7.7	320
Minimum		370	206	0.03	12	0.6	7.3	198
Town of Hespeler	91							
Average		341	270	0.58	25	-	7.5	-
Maximum		448	338	1.88	48	-	7.6	-
Minimum		286	233	0.05	9	-	7.3	-
Town of New Hamburg	10							
Average		297	244	0.22	15	0.2	7.7	-
Maximum		439	290	0.36	37	0.2	8.1	-
Minimum		206	192	0.00	4	0.1	7.5	-
Town of Paris	27							
Average		268	234	0.07	16	0.1	7.7	-
Maximum		360	272	0.52	20	0.2	8.0	-
Minimum		230	176	0.00	7	0.0	7.4	-
Town of Preston	29							
Average		317	243	0.14	26	0.3	7.5	-
Maximum		394	280	0.75	51	0.5	7.8	-
Minimum		263	190	0.05	8	0.1	7.4	-
Village of Elora	10							
Average		545	207	0.20	20	0.4	7.6	353
Maximum		592	214	2.00	24	0.6	8.0	379
Minimum		520	203	0.01	16	0.3	7.4	299

TABLE IV-6

MUNICIPAL AND INDUSTRIAL WATER USAGE

Municipality	Pumped by Municipality (Ground Water) Total (mgd)	Domestic & Commercial (mgd)	Industrial (mgd)	Private Industrial Supplies* Surface Water (mgd)	Ground Water (mgd)
Cities					
Galt	4.01	2.70	1.31	0.04	-
Guelph	5.19	4.66	0.53	0.68	-
Kitchener	9.19	4.90	4.29	0.03	1.11
Waterloo	2.39	1.79	0.60	-	0.06
Towns					
Elmira	1.36	0.26	1.10	0.06	-
Fergus	0.45	0.39	0.06	-	0.08
Hespeler	0.43	0.29	0.14	1.61	-
New Hamburg	0.19	0.17	0.02	-	-
Paris	0.60	0.52	0.08	0.36	-
Preston	1.44	0.94	0.50	0.35	0.04
Villages					
Ayr	-	-	-	-	-
Bridgeport	-	-	-	-	-
Elora	0.13	0.13	-	-	-
Wellesley	-	-	-	-	0.02
Townships					
Wilmot	-	-	-	-	0.77
Woolwich	-	-	-	0.01	0.01
TOTALS	25.38	16.75	8.63	3.14	2.09

* - Exclusive of usage covered by permits to take water

TABLE IV-7

WATER USAGE (MGD)

COUNTY	RURAL DOMESTIC GROUND WATER	LIVESTOCK GROUND & SURFACE WATER	FARM CROPS & NURSERIES (1) GROUND WATER	FARM CROPS & NURSERIES (1) SURFACE WATER	GOLF COURSES (2) GROUND WATER	GOLF COURSES (2) SURFACE WATER	COMMERCIAL (1) GROUND WATER	MUNICIPAL EXCLUDING INDUSTRIAL GROUND WATER	INDUSTRIAL (1) GROUND WATER	INDUSTRIAL FROM MUN. AND PRIVATE SUPPLIES GROUND WATER	INDUSTRIAL FROM MUN. AND PRIVATE SUPPLIES SURFACE WATER
BRANT	0.27	0.23	-	0.28	-	-	0.12	0.52	-	0.08	0.36
HALTON	0.04	0.04	-	-	-	-	-	-	-	-	-
OXFORD	0.16	0.30	-	0.36	-	-	-	-	-	-	-
PERTH	0.02	0.06	-	-	-	-	-	-	-	-	-
WATERLOO	1.51	1.73	0.01	0.57	-	0.36	0.09	11.05	1.43	9.97	2.10
WELLINGTON	0.57	0.91	0.16	0.13	0.05	0.17	0.22	5.18	0.69	0.67	0.68
WENTWORTH	0.17	0.02	-	-	-	0.09	-	-	-	-	-
TOTAL	2.74	3.29	0.17	1.34	0.05	0.62	0.43	16.75	2.12	10.72	3.14

NOTE: (1) DURING JUNE AND JULY ONLY-NOT COMPLETE - LACK OF INFORMATION

(2) FROM MAY TO OCTOBER ONLY

TOTAL GROUND WATER	-	32.98 MGD
TOTAL SURFACE WATER	-	5.10 MGD
UNDIFFERENTIATED	-	3.29 MGD
TOTAL	-	41.37 MGD

V

WATER SUPPLY REQUIREMENTS

EXISTING FACILITIES

All of the municipalities within the study area, with the exception of the Village of Ayr and the Townships of Dumfries North, Guelph, Nichol, Pilkington and Puslinch, have one or more communal water supplies. All of these systems utilize ground-water sources by means of wells and/or springs. A summary of the water sources, nominal supply capacities, treatment facilities, available storage and system services is given in Table V-1. It should be noted that, in general, all of the communal raw-water supplies are very hard, high in alkalinity and contain iron in excess of the recommended maximum of 0.30 ppm. The raw water quality of the municipal systems and the various aquifers in the region is given in Section IV. The locations of the various municipal and private wells are shown on Figure IV-2.

The larger municipalities in the region such as the Cities of Kitchener and Guelph have continuing exploration programmes to locate additional ground-water supplies. The smaller municipalities undertake exploration programmes periodically as the need for increased supplies arises.

GENERAL CONSIDERATIONS

Various available sources of water supply were considered in relation to the anticipated development in the area. A summary of these is as follows:

(a) Ground water

(b) Impoundment reservoirs on the Grand River and its tributaries

(c) Lake Erie via an extension to the proposed Lower Grand Valley Regional Water Supply System

(d) Lake Huron via a separate system with a treatment plant near Grand Bend or via an extension to the Lake Huron Water Supply System

(e) Georgian Bay via a system with a treatment plant at Collingwood or possibly north of Fergus

(f) Lake Ontario via a system with a treatment plant at Burlington

(g) A combination of the above

The pattern that development in the region is apparently following indicates that it would not be feasible to supply some of the smaller municipalities located towards the boundaries of the study area with water from a central system. For instance, it is doubtful that a supply system from Lake Erie to the major population centres in the Galt-Kitchener-Guelph area would be extended to serve the Town of Fergus or the Village of Elora. Therefore it was concluded that the smaller municipalities should continue to obtain their water from local ground sources. Fortunately, it appears that this will be possible for all of the municipalities that are categorized thus. These include the Towns of Elmira, Fergus, New Hamburg and Paris, and the Villages of Ayr, Elora and Wellesley.

Future use of ground and surface waters for agricultural purposes was also considered. In general it was concluded that the amount of water to be utilized for stock watering, crop irrigation and general farm purposes was small in relation to the total required for urban development. The farm needs were roughly assessed, with the conclusion that adequate water would be available from ground and surface sources within the region to satisfy these requirements.

DESIGN

The evaluation of the water supply requirements for the area was based on the population projections given in Table III-1

and the present, and estimated future water use in the area.

The current per capita demand figures in the region vary from 73 to 127 gallons per day. For the purpose of this report, the following criteria were used. It should be noted that these figures include gradual increases in the per capita demand from year to year. Such increases have been known to occur due to modern innovations in home and industry.

Year		Average Per Capita Demand (gpd)	Maximum Per Capita Demand (gpd)	Maximum Hourly Per Capita Demand (gpd)
1971	Cities & Preston	115	230	345
	Remaining Towns and Villages	90	180	270
1976	Cities & Preston	125	250	375
	Remaining Towns and Villages	95	190	285
1986	Cities & Preston	135	270	405
	Remaining Towns and Villages	105	210	315
Ultimate	Cities & Preston	180	360	540
	Remaining Towns and Villages	140	280	420

The different consumption figures for cities as opposed to towns and villages were used because there appeared to be a similar difference in the records of previous years. The "city" per capita demand figure was used for the Town of Preston as current demand figures approximated those of the four cities in the region.

The preceding per capita consumption figures were intended to provide for all residential, industrial and commercial development with the exception of any extremely large water-using industry.

The water purification plant capacities were based on the maximum day requirements for the areas served. Pumping stations were similarly sized to supply the maximum day demand. Pumping

reservoirs were sized to provide two hours storage at the maximum hourly rate of demand. Supply reservoirs were sized to provide one day storage at maximum day demand for the area served.

Individual municipal storage requirements as shown on Table V-2 were based on the following considerations.

(1) Operating Storage - 25 per cent of the maximum daily flow for equalizing peak hourly demands

(2) Fire Storage - In accordance with the "Standard of Municipal Fire Protection" prepared by the Canadian Underwriters' Association

(3) Emergency Storage - 25 per cent of the total storage volume provided by the reservoir

A Hazen-Williams "C" factor of 130 and a head loss of approximately one foot per 1,000 feet of pipe have been used to calculate pipe diameters. Only trunk feeder mains have been considered.

SOURCE

Ground Water

Section IV indicates that the amount of good quality ground water potentially available for future development is approximately 22 mgd. The same section indicates that the Kitchener-Waterloo-Bridgeport complex may have difficulty obtaining adequate amounts of ground water close to the municipal boundaries.

It is probable that sufficient quantities of ground water to serve Galt, Preston, Hespeler and Guelph until at least 1976 can be developed near or within their respective municipal boundaries. However, adequate storage facilities should be built in each municipality to meet maximum day and hourly rates of demand.

It is not considered practical to utilize the ground water in this region for the main source of supply with supplementation by water from a surface source. The main reason for this is the impracticality of providing a uniform water quality to all consumers at all times. A surface-water supply from one of the

Great Lakes would be approximately one-quarter as hard as the ground water in the area and would have very little iron content. The situation where a municipality would charge the same rate to consumers for two different water qualities where one quality is obviously superior would seem to be inequitable. Another difficulty would be the possible technical problem that might arise when two water qualities are blended or may be in contact.

Impoundment Reservoirs

At present there are three impoundment reservoirs in the Grand River Watershed; Belwood Lake, Conestogo Lake, and Luther Lake. Several other reservoirs are planned for the future. The desirability of utilizing these bodies of water for domestic supply purposes is doubtful.

In general, the topography in the Grand Valley is not suitable for the construction of dams that would impound water to a satisfactory depth. Reservoirs should be fairly deep, averaging 40 to 50 feet, in order to minimize the effect of surface pollutants and the occurrence of frazil ice conditions in a water works intake. If an impoundment reservoir is used for water supply, its use for other purposes such as recreation, flood control and flow augmentation will be restricted to some extent.

A second difficulty is that the Grand River is a 'fertile' watercourse. By this, it is meant that the levels of nitrogen and phosphorus and their compounds in the water are such that excessive weed and algae growths may occur. These growths, in turn, may cause taste, odour, and filter clogging problems in a water treatment plant. The water quality outlined in Section IV supports this conclusion.

In regard to the general chemical and physical characteristics

of river water it can be said that the turbidity and colour levels are usually higher than natural lake water. This result is higher costs for the construction of the treatment works and higher operating costs thereafter. It is true that impoundment of river water might possibly reduce turbidity and colour levels, the bacterial population and, to a certain extent temperature. This would generally improve the treatability of the river water.

A further consideration that must be made in this instance is the fact that with the rapid development occurring within this watershed an increasingly important use of the watercourses will be the dilution of waste effluents. The use of the river for supply purposes would seriously reduce the amount available for dilution purposes.

It is apparent therefore that, due to the poorer quality of the river water as compared to the water in the Great Lakes, and the expected demand on the rivers for dilution of waste effluents, impoundment reservoirs in the Grand River Watershed cannot be considered as sources of domestic water supply.

Lake Erie

Water could be supplied to the study region from Lake Erie through enlargement and extension of the proposed Lower Grand Valley Regional Water Supply System which was designed to serve Brantford, Caledonia, Cayuga, Hagersville and Jarvis. Although the raw water quality is good, a very long intake is required to obtain satisfactory water depth and treatment costs may be somewhat higher than those incurred using either Lake Ontario or Lake Huron water. An economic study may indicate which source, available at a lesser cost, will provide an equally satisfactory water quality.

Lake Huron

Lake Huron is a suitable source of supply for the study area; however, it is approximately 40 miles farther from the study area than Lake Ontario and 20 miles farther than Lake Erie (see Figure V-1). The static head to be overcome on a route from Grand Bend is comparable to that on a route from Lake Erie at Peacock Point and approximately 230 feet less than that from Lake Ontario. An intake approximately equal in length to that required for a Lake Erie system but more than 5,000 feet longer than a Lake Ontario system would be required to obtain the same water depth. An advantage of this source is that it might be possible to supply water to Stratford; however, this municipality's consumption is relatively small.

The utilization of the Lake Huron Water Supply System by a pipeline from Arva to the study area was considered. This route from Arva is approximately 6 miles longer than a Lake Erie system and 26 miles longer than a Lake Ontario system. In addition, the Lake Huron Water Supply System capacity would have to be more than doubled to meet the estimated 1986 demand in the study area. While this route could serve both Woodstock and Stratford in addition to the study area, the water consumption of these two municipalities probably would not offset the additional capital expenditures required.

Georgian Bay

Georgian Bay is the source of the best quality water of all the sources considered in this report. Unfortunately, its distance from the Middle Grand River Region would necessitate expendures that are too great to be practical. The capital cost of a pipeline from Georgian Bay to the study area would be approximately the same as for a similar system from Grand Bend on

Lake Huron. Pumping costs would be increased because of the static head to be overcome. The static heads to be encountered on the Lake Ontario, Lake Huron and Lake Erie systems are 854 feet, 620 feet and 530 feet respectively. The static head to be overcome for a system from Georgian Bay is 1,170 feet.

It should be noted that there are no municipalities "on route" from Georgian Bay that could utilize the system with the possible exceptions being the Town of Fergus and the Village of Elora.

Lake Ontario

The Middle Grand River Region is closer to Lake Ontario than any of the other Great Lakes. Other advantages of Lake Ontario as a source of supply are that an adequate depth of water can be obtained close to shore and the water quality is satisfactory. Power costs for operating a system to supply the region would be greater than for a Lake Erie system. However, the reduced length of pipeline should more than compensate for this.

If Lake Ontario should be chosen as the most suitable source of supply, it is possible that some provision could be made to supply the Town of Milton at some later date. The north half of the Town of Burlington could also be served.

Combinations

Since the ease and capital cost required to obtain adequate supplies of good quality ground water varies within the larger municipalities in the study area, it may be advantageous to supply lake water to only one or two of the municipalities at this time from one source, with provision of another system from a different source to supplement and expand the first system at a later date. For instance, the Kitchener-Waterloo-Bridgeport complex will find it expensive and perhaps difficult to find

enough good quality ground water to serve the municipalities for more than ten years. A surface supply system from one source to serve until 1986 with provision for a second system to supplement and provide water for the entire Kitchener-Galt-Guelph region beyond this date might be practical.

As discussed previously in this section under "Ground Water", it appears to be impractical to utilize surface water to supplement ground water within the same municipality.

WATER SUPPLY ALTERNATIVES

Two alternatives exist for the supply of surface water to the area. The first (Alternative 1) is the provision of water from one of the Great Lakes to the Kitchener-Waterloo-Bridgeport complex immediately, with a second system to serve all of the lands bounded by the Guelph-Galt-Kitchener triangle in the future. The second alternative considers the provision of surface water to all of the larger municipalities at an early date.

The implementation of either of these schemes depends to a large degree on the co-operation and foresight of the municipalities concerned.

PROPOSED WORKS

Economic studies have been undertaken on each of the aforementioned possibilities and only the most reasonable systems will be described in this section.

Alternative 1

Due to the limited ground-water resources close to the Kitchener-Waterloo-Bridgeport area, an alternative source of water supply is required in the near future. Since the remainder of the large municipalities will require an alternate source not later than 1986, the total works could be staged accordingly.

This alternative provides for enlargement and extension of the Lower Grand Valley Regional Water Supply as reported by the firm of James F. MacLaren Limited, Consulting Engineers, in its report to the Commission dated January 1966. The new proposal would be capable of supplying 85.11 mgd, the 1986 maximum day demand for the area served. The proposal would consist of:

(1) Intake at Peacock Point in a water depth of 30 feet

(2) Complete water treatment plant at Peacock Point and pumping station

(3) Pipeline from Peacock Point to reservoir at Brantford

(4) Pipeline from Brantford to Kitchener-Waterloo-Bridgeport area

(5) Reservoir (13 mg) at Brantford

(6) Terminal Reservoir (60 mg) near Kitchener-Waterloo-Bridgeport

(7) Reservoir (1.00 mg) near Jarvis to serve Lower Grand municipalities

(8) Pumping station at Brantford

(9) Pumping station and pipelines as described in the MacLaren report to serve Jarvis, Hagersville, Cayuga and Caledonia

This route would require a pipeline approximately 51.6 miles long from Peacock Point to the Kitchener-Waterloo-Bridgeport area. The possible route is shown on Figure V-1.

A second system utilizing Lake Ontario could be built by approximately 1986 to serve the remainder of the study area. This would entail a pipeline 40.6 miles long from Burlington to Highway No. 7 between Guelph and Waterloo. A more reliable estimate of the growth beyond 1986 would then be available. This method would permit unlimited growth and water use in both the Brantford and Kitchener-Waterloo-Bridgeport areas since the timing of the second system could be adjusted to meet the demand. In addition, should the Galt-Preston area require surface water

before 1986, the Lake Erie system capacity could be increased by the provision of additional pumping stations.

Alternative 2

Should all or the majority of the large municipalities in the study area agree to use surface water at an early date, a system utilizing Lake Ontario should be provided. The separate system as described in the MacLaren report would be utilized for the Lower Grand Valley.

The Lake Ontario system would be capable of delivering 111.44 mgd and would consist of:

(1) Intake at Burlington for 30+ feet of water

(2) Complete water treatment plant and pumping station

(3) Pipeline from water treatment plant to Booster Station No. 1

(4) Pipeline from Booster Station No. 1 to Galt-Preston reservoir

(5) Pipeline from Galt-Preston reservoir to terminal reservoir near Highway No. 7

(6) Pumping Reservoir (14 mg) at Booster Station No. 1

(7) Reservoir (23 mg) at Galt-Preston

(8) Reservoir (2 mg) at Hespeler

(9) Terminal reservoir (85 mg) near Highway No. 7

(10) Pumping station at Booster Station No. 1

The capacity of this system could be increased through the use of intermediate pumping stations; however, it does not possess the flexibility of Alternative 1. This system could also be utilized by the northern portion of the Town of Burlington. If necessary water could also be supplied to the Town of Milton.

CONCLUSIONS

An urban population of 213,889 persons were resident in the Galt-Guelph-Kitchener triangle in 1965. It is likely that this figure will increase to an equivalent population of 415,500 by

1986 and ultimately to greater than one million persons.

Limited good quality ground water is available adjacent to the Kitchener-Waterloo-Bridgeport complex for future development. Sufficient ground water for potable purposes probably is available near the Galt, Preston, Hespeler and Guelph areas to serve until near 1986. The communities of Elmira, Fergus, New Hamburg, Paris, Ayr, Elora and Wellesley and the rural areas can likely obtain adequate quantities of good quality ground water for the foreseeable future.

Although there are large watercourses in the study area, these are not suitable as sources for a large water supply system. The reasons for this include unsuitable topography to obtain adequate impounded water depths, a 'fertile' water, probable operational difficulties and the need for use of all of the available flows for future effluent dilution purposes.

All of the Great Lakes are suitable for use as a raw water supply for potable purposes. The approximate pipeline distances from each of the possible sources to serve the entire study area are:

From	Approximate Pipeline Length (Miles)
Lake Ontario	40.6
Lake Erie	61.7
Lake Huron	75.0
Georgian Bay	75.0

Only the Kitchener-Waterloo-Bridgeport complex requires an alternate supply at this time. The most reasonable means of accomplishing this is through enlargement and extension of the proposed Lower Grand Valley Regional Water Supply System. A second system from Lake Ontario to supplement the previous system could be built at a later date.

Should all of the large urban municipalities in the study area desire surface water at this time, a Lake Ontario oriented system would be developed.

The 1986 demands for the Galt-Guelph-Kitchener triangle are average and maximum days of 55.72 and 111.44 mgd respectively with ultimate demands of 171.80 and 343.60 mgd for average and maximum days respectively.

It may be practical at some future date to interconnect the Lake Huron Water Supply System, when it is extended, and the proposed Southern Peel County Area Water Supply System with the proposed Middle Grand River Region Water Supply System. This would provide great flexibility in the operation of all systems and would make possible the unlimited supply of good quality water to a large area of the Province.

TABLE V-1

COMMUNAL WATER SOURCES, CAPACITIES, TREATMENT, STORAGE AND SERVICES

Municipality	Source of Supply	Nominal Capacity of Works (mgd)	Treatment Provided	Storage	No. of Services	Remarks
City of Galt	9 Wells	9.55	None	2.65 mg ground 1.01 mg elevated	8,354	
City of Guelph	18 Wells	11.79	Calgon and chlorination at one well	4.00 mg ground	11,400	
	3 Springs		Chlorination at springs	1.50 mg elevated		
City of Kitchener	23 Wells	14.50	None	14.50 mg ground 1.40 mg elevated	21,300	
City of Waterloo	7 Wells	5.53	None	2.90 mg ground 0.79 mg elevated	5,370	
Town of Elmira	3 Wells	2.00	None	0.60 mg ground 0.36 mg elevated	1,495	
Town of Fergus	3 Wells	1.51 (0.86 good quality)	Chlorination on one well	0.25 mg ground 0.21 mg elevated	1,362	
Town of Hespeler	7 Wells	2.10 (0.88 good quality)	Aeration and Chlorination at two wells	0.23 mg ground 0.10 mg elevated	1,507	
Town of New Hamburg	1 Well 1 Spring	0.66	Chlorination at springs	0.60 mg ground 0.12 mg elevated	626	
Town of Paris	1 Well 2 Springs	1.31	Chlorination of spring water	1.20 mg ground	2,115	
Town of Preston	8 Wells 1 Spring	3.46 (1.49 good quality)	Chlorination of 2 wells and spring	1.80 mg ground 0.13 mg elevated	3,343	
Village of Elora	2 Wells	0.66	Calgon and chlorination	0.12 mg elevated	472	

TABLE V-1
(Cont'd)

COMMUNAL WATER SOURCES, CAPACITIES, TREATMENT, STORAGE AND SERVICES

Municipality	Source of Supply	Nominal Capacity of Works (mgd)	Treatment Provided	Storage	No. of Services	Remarks
Private Systems						
City of Waterloo						
1. Colonial Acres Subdivision	1 Well	0.39	Softening and Iron Removal (Ion Exchange)	None	25	In area annexed from Township of Waterloo
Village of Wellesley						
1. Wagner	1 Well	0.05	None	0.01 mg ground	115	
2. Lichti	1 Well	0.29	None	None	10	
Township of Dumfries South						
1. P.V. of St. George	2 Wells	0.19	None	0.035 mg	190	
Township of Waterloo						
1. Chalon Estates	1 Well	0.68	None	0.008 mg	8	Planned for 126 services
2. Eastmount Subd.	1 Well	0.25	None	0.001 mg	50	Immediately east of Kitchener
3. Elroy Acres	2 Wells	0.25	None	0.001 mg	60	Immediately south of Breslau
4. Schweitzer Subd.	2 Springs	N.A.	None	None	7	Lot 125, G.C.T.
Township of Wellesley						
1. Linwood	2 Wells	0.02	None	N.A.	12	Owned by Police Village
2. Luntz	1 Well	0.02	None	None	14	Located in Linwood
3. Ogram	1 Well	0.02	None	None	26	" " "
4. Erb	1 Well	0.03	None	None	10	West of Wellesley
5. Heidelburg School	1 Well	0.02	None	None	16	Located in Heidelburg

TABLE V-1
(Cont'd)

COMMUNAL WATER SOURCES, CAPACITIES, TREATMENT, STORAGE AND SERVICES

Municipality	Source of Supply	Nominal Capacity of Works (mgd)	Treatment Provided	Storage	No. of Services	Remarks
Twp. of Wilmot						
1.Hamacher	1 Well	0.02	None	None	13	Located in New Dundee
2.Hannon	1 Well	0.02	None	None	18	Located in St. Agatha
3.Schwartzentruber	1 Well	0.04	None	0.001 mg	20	Located near St.Agatha
4.Knipfel	1 Well	N.A.	N.A.	N.A.	45	Proposed for Subdivision
Twp. of Woolwich						
1.Good Subdivision	1 Well	0.06	None	None	N.A.	Located in St.Jacobs
2.Martin's Grove Mobile Home Park	1 Well	0.04	None	None	30	

TABLE V - 2

WATER SUPPLY REQUIREMENTS

MUNICIPALITY	1965				1971			1976			1986			ULTIMATE		
	FLOW		STORAGE		FLOW		STORAGE*	FLOW		STORAGE*	FLOW		STORAGE*	FLOW		STORAGE*
	AVG. DAY (MGD)	MAX. DAY (MGD)	REQUIRED (MG)	PROVIDED (MG)	AVG. DAY (MGD)	MAX. DAY (MGD)	REQUIRED (MG)	AVG. DAY (MGD)	MAX. DAY (MGD)	REQUIRED (MG)	AVG. DAY (MGD)	MAX. DAY (MGD)	REQUIRED (MG)	AVG. DAY (MGD)	MAX. DAY (MGD)	REQUIRED (MG)
CITIES																
GALT	4.013	6.365	5.40	3.66	4.40	8.80	6.42	5.60	11.20	7.48	8.32	16.64	9.70	27.00	54.00	23.78
GUELPH	5.186	7.434	6.45	5.50	6.68	13.36	8.61	8.51	17.02	10.05	12.64	25.28	13.48	36.00	72.00	30.00
KITCHENER	9.193	14.733	10.03	15.90	12.05	24.10	13.43	15.35	30.70	15.96	22.80	45.60	21.38	72.00	144.00	55.20
WATERLOO	2.389	4.405	4.60	3.69	3.89	7.78	5.88	4.95	9.90	6.85	7.36	14.72	8.95	22.50	45.00	20.46
SUB-TOTAL	20.781	32.937	26.48	28.75	27.02	54.04	34.34	34.41	68.82	40.34	51.12	102.24	53.51	157.50	315.00	129.44
TOWNS																
ELMIRA**	0.359	0.720***	1.20	0.96	0.42	0.84	1.50	0.52	1.04	1.82	0.74	1.48	2.11	2.10	4.20	3.64
FERGUS	0.402	0.820	1.30	0.46	0.45	0.90	1.56	0.54	1.08	1.86	0.77	1.54	2.15	2.10	4.20	3.64
HESPELER	0.429	0.849	1.56	0.33	0.54	1.08	1.91	0.65	1.30	2.03	0.90	1.80	2.34	2.10	4.20	3.64
NEW HAMBURG	0.190	0.500	0.85	0.72	0.24	0.48	0.88	0.29	0.58	1.06	0.41	0.82	1.23	1.40	2.80	2.75
PARIS	0.596	1.192***	1.96	1.20	0.60	1.20	2.00	0.66	1.32	2.06	0.84	1.68	2.25	1.68	3.36	3.12
PRESTON	1.444	2.888***	3.02	1.93	1.74	3.48	3.41	2.21	4.42	3.90	3.29	6.58	5.01	10.80	21.60	11.25
SUB-TOTAL	3.420	6.969	9.89	5.60	3.99	7.98	11.26	4.87	9.74	12.73	6.95	13.90	15.09	20.18	40.36	28.04
VILLAGES																
AYR	NO COMMUNAL WATER WORKS				0.12	0.24	0.43	0.15	0.30	0.50	0.22	0.44	0.71	0.70	1.40	1.73
BRIDGEPORT	PRESENTLY OBTAINS WATER FROM KITCHENER				0.22	0.44	0.84	0.27	0.54	0.91	0.41	0.82	1.23	1.40	2.80	2.75
ELORA	0.113	0.378	0.51	0.12	0.17	0.34	0.65	0.21	0.42	0.80	0.32	0.64	0.96	1.05	2.10	2.34
WELLESLEY	NO MUNICIPAL WATER WORKS				0.07	0.14	0.30	0.09	0.18	0.31	0.14	0.28	0.45	0.42	0.84	1.02
SUB-TOTAL	0.113	0.378	0.51	0.12	0.58	1.16	2.22	0.72	1.44	2.52	1.09	2.18	3.35	3.57	7.14	7.84
TOTAL	24.314	40.284	36.88	34.47	31.59	63.18	47.82	40.00	80.00	55.59	59.16	118.32	71.95	181.25	362.50	165.32

* - IF THE SOURCE OF SUPPLY IS REMOTE FROM THE POPULATION CENTRES, ADDITIONAL STORAGE EQUIVALENT TO ONE MAXIMUM DAY WILL BE REQUIRED IN THE MUNICIPALITY.

** - EXCLUDING WATER UTILIZED BY NAUGATUCK CHEMICALS

*** - ESTIMATED

LIST OF ABBREVIATIONS

Twp.	-	Township
P.V.	-	Police Village
Cr.	-	Creek
Hr.	-	Harbour
L.	-	Lake
R.	-	River
N.	-	North
S.	-	South
cfs	-	cubic feet per second
gal.	-	gallons (Imperial)
gpm	-	gallons per minute (Imperial)
gpd	-	gallons per day (Imperial)
mgd, MGD	-	million gallons per day (Imperial)
mg	-	million gallons (Imperial)
ml	-	millilitres
ppm	-	parts per million
ppb	-	parts per billion
sq. mi.	-	square miles
Lab.	-	Ontario Water Resources Commission Laboratories
No.	-	Number
Max.	-	Maximum
Min.	-	Minimum
Avg.	-	Average
Susp.	-	Suspended
Cont'd	-	Continued
Subd.	-	Subdivision
BOD	-	Biochemical Oxygen Demand
M.F.	-	Membrane Filter
N.A.	-	Not Available
GRCA	-	Grand River Conservation Authority
OWRC	-	Ontario Water Resources Commission
G.C.T.	-	German Company Tract

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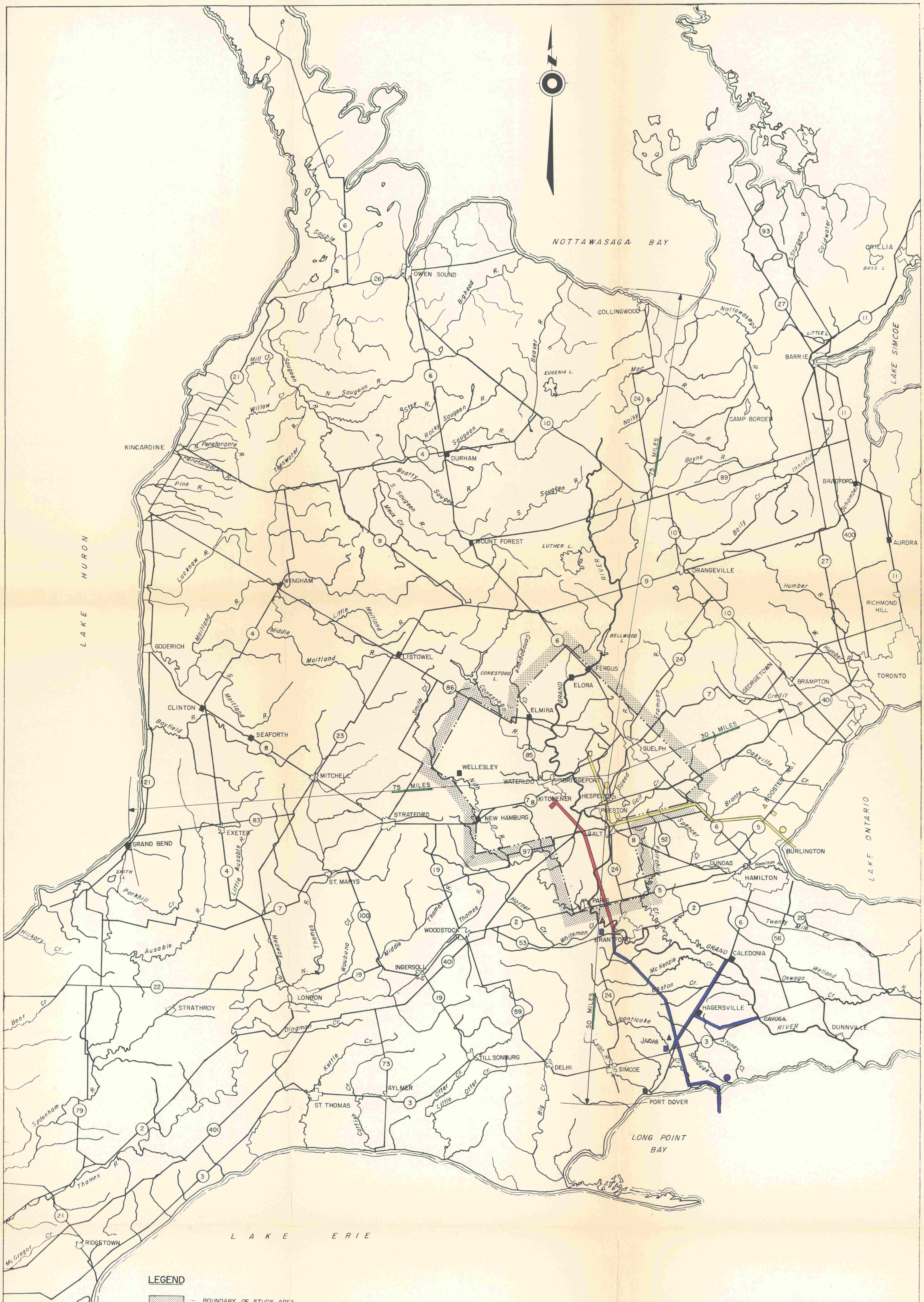

ONTARIO WATER RESOURCES COMMISSION

MIDDLE GRAND RIVER REGION
WATER SUPPLY STUDY
PROPOSED WATER SUPPLY SYSTEMS
FIGURE V – I

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CHECKED BY : K.L.	DRAWING No: 66-78